PYROTECHNICAL SAFETY OF AEROSPATIALE TACTICAL MISSILES - APPLICATION TO CONVENTIONAL WARHEAD

Alain GRAVE

AEROSPATIALE Division Engins Tactiques
2 rue Béranger,
92322 CHATILLON CEDEX, FRANCE

ABSTRACT : This paper begin with a qualitative review of some past safety tests done on various AEROSPATIALE in-service conventional warheads. The diversity of test configurations - fuel fire, bullet impact and sympathetic detonation - is shown, and, despite the difficulty of comparison with current standard tests, the situation is resumed. In a second part, the work on the second generation EXOCET anti-ship warhead, for which safety specifications were defined, is described. The use of PBX explosive loading permitted to satisfy the safety requirements. Finally, some aspects of current AEROSPATIALE studies and developments from a safety point of view, are given.

1. INTRODUCTION

Nearly all of the AEROSPATIALE Tactical Missiles in production have been tested by 12-meter drop, fuel fire, bullet impacts and sympathetic detonation. These tests were applied, sometimes on a complete missile, always on major pyrotechnical sub-assemblies, i.e. warhead and propellant. They were done in different configurations, according to each weapon system requirements. This paper is limited to conventional warheads, and drop tests are not considered.

Up to now, in all cases except one, the safety tests were "statement type", i.e. they were achieved a posteriori, as evaluation tests, on qualified equipments that were designed only for optimal terminal ballistic performances. In para. 2, some examples of these tests are described.

The above exception is the EXOCET anti-ship missile second generation warhead. Safety tests were done during feasibility and development phases, in accordance with the specified safety performance requirements. This is the subject of para. 3.

Finally, some aspects of current AEROSPATIALE studies and developments from a safety point of view, are described in para. 4.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **AUG 1990**	2. REPORT TYPE	3. DATES COVERED **00-00-1990 to 00-00-1990**
4. TITLE AND SUBTITLE **Pyrotechnical Safety of Aerospatiale Tactical Missiles - Application to Conventional Warhead**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Aerospatiale Division Engins Tactiques,2 rue Beranger,92322 Chatillon Cedex, France,**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADA235005, Volume 1. Minutes of the Explosives Safety Seminar (24th) Held in St. Louis, MO on 28-30 August 1990.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

2. EXAMPLES OF SAFETY TESTS PERFORMED ON WARHEADS

The tests described in this chapter do not represent the entire range of tests. They are simply aimed at illustrating the various test methods and the insensitivity levels obtained with the current warheads.

2.1. Fuel fire tests

The main characteristics for some of these tests are detailed in the table below :

Weapon system	Test date	Fuel volume	Fire dimensions	Fuel/ specimen height	Specimen configuration
EXOCET	04.74	1600 l	6 x 2 m^2	0.17 m	Missile mock-up in inclined container
HOT	10.72	10 l	1.5 x 0.5 m^2	0.4 m	Missile in tactical package
MILAN 2	09.83	10+30 l	"	"	"
MILAN 2	09.83	30 l	"	"	"
HOT 2	10.84	20 l	"	"	"

The EXOCET anti-ship warhead is characterized by a strong steel confinement and a composition-B cast explosive loading. The fuel fire test produced a violent pyrotechnical reaction after a few minutes.

For the HOT and MILAN anti-tank shaped charges, the confinement, on the contrary, is very moderate. With both the 1st generation RDX basis and 2nd generation HMX basis cast explosive loadings, the pyrotechnical reaction was limited to combustion of the explosives.

2.2. Bullet impact tests

This type of test was performed under various conditions, as shown by the table next page :

Weapon system	Date	Warhead configuration	Type of agression
EXOCET	04/74	In container	1 shot, using a 12.7 mm AP bullet
ROLAND	03/76	Bare warhead	1 burst of five 12,7 mm bullets (1 tracer + 2 incendiary + 2 AP)
HOT	10/72	Bare warhead	5 shots, 7.5 mm bullet (standard/tracer/standard/standard/tracer)
HOT 2	10/84	Warhead in tactical package	1 shot with standard 7.62 mm bullet 1 shot with 20 mm APT round 1 shot with 23 mm explosive round

As for the fire tests, only moderately confined charges (HOT-ROLAND) were measured, producing pyrotechnical reactions limited to combustion, using a RDX-TNT or HMX-TNT cast explosive loading.

Special attention was sometimes given to the initiating device, with certain firings aimed at reaching this device. Thus for example, the five consecutive firings on the same HOT warhead were performed in the chronological order shown in figure 1. No reaction was produced by these firings.

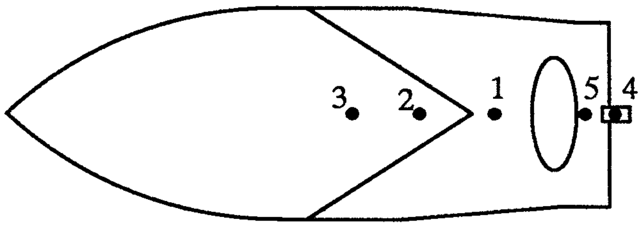

figure 1 : Bullet impacts on HOT warhead

For the highly confined warhead (EXOCET), a violent pyrotechnical reaction was produced with splinter projection (composition-B explosive). A series of specific tests showed that the reaction appeared once the bullet obtained sufficient velocity to just perforate the steel case of the warhead, and come into contact with the explosive loading.

2.3. Sympathetic detonation tests

All of the tests of this type performed on warheads currently in service resulted in propagation of the detonation of the initiated warhead (transmitter or donor) to the nearby warheads (receivers or acceptors). The example in figure 2 shows the test configuration used for the HOT and

MILAN missile rounds : logistic package, comprising four tactical packages, two of which contained live missile rounds.

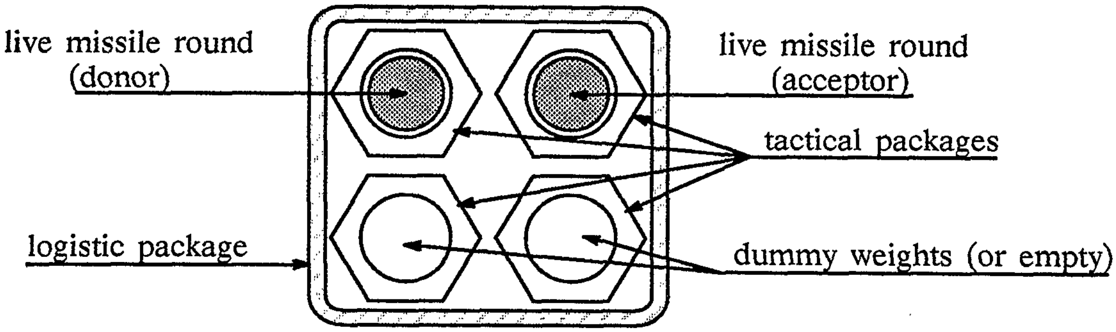

figure 2 : Sympathetic detonation test configuration for anti-tank missiles

This led to performing certain specific tests to ensure safety under both factory and operational conditions. These tests were aimed at studying the intermediate protections required and sufficient to avoid transmission of the detonation from one warhead to another. For instance, the test showed that a wood protection with a thickness of 4 cm inhibited transmission of the detonation between two ROLAND warheads. The same applies between two EXOCET warheads in container, using a 12.7 mm thick steel plate.

2.4. Conclusions on these tests

Despite the diversity of test configurations used in the past, and the difficulty in comparing these tests with current standard tests, the situation can be resumed as follows:

- The highly confined 1st generation warheads (EXOCET, etc.), with composition-B explosive loading, have a high degree of sensitivity and do not satisfy any of the three major safety test requirements.
- The moderately confined warheads, 1st and 2nd generation, using RDX or HMX basis cast explosive, could satisfy the safety requirements relative to two of the three safety tests : fuel fire and bullet impacts.

These observations led the French Ministry of Defence to issue us the contracts for research and development of the 2nd generation EXOCET warhead, covered in the next paragraph.

3. SECOND GENERATION EXOCET WARHEAD

The work on this warhead was performed in three phases: general research, feasibility and development under contract to the French Ministry of Defence. The technical specifications defined two major goals: safety level (fuel fire and bullet impact) and terminal efficiency performance level. The safety portion was carried out in collaboration with the SNPE.

3.1. General study phase

This phase took place between 1975 and 1978 and resulted in testing of three composite explosives (PBX) using plastic binder, proposed by the SNPE, comprising :

Explosive	HMX %	RDX %	Aluminium	Plastic binder %
A	70	0	18	12
B	0	84	0	16
C	86	0	0	14

During this phase, four fuel fire tests and two bullet impact tests were performed. The charges consisted of full-scale EXOCET bodies in which the explosive to be tested was polymerised. The tests were performed on the bare warhead with slightly varying parameters. However, all of the impact tests consisted of a single shot using a 12.7 mm AP bullet.

The encouraging results obtained from the very start of this phase made it possible to initiate the feasibility phase as of 1977.

At the end of this phase, the C-type explosive was selected, providing the best performance/safety compromise. The A-type explosive in particular, providing a higher performance level, was not selected due to its excessive degree of sensitivity.

3.2. Feasibility phase

This phase took place between 1977 and 1981 and was mainly aimed at optimizing terminal ballistic performance. The safety tests performed at the end of this phase reinforced the results obtained in the preceding phase, taking account of the changes in the definition of the warhead.

One fuel fire test and four bullet impact tests were performed during this phase with the following characteristics:

- For all the tests, the warhead was fitted, at the front and rear, with dummy weights representative of the weights of the EXOCET missile, in view of simulating the axial confinement of the warhead. This test specimen was not placed in a launch tube.
- For the fuel fire test, the fuel-specimen height was set at 47 cm.
- The bullet impact test was performed by a single shot using a 12.7 mm AP bullet. Certain charges were subjected to a second, and sometimes third, bullet impact when their condition after a firing so permitted.

3.3. Development phase

This phase took place between 1982 and 1985 and was completed by qualification tests of the EXOCET missile second generation warhead.

One fuel fire test and one bullet impact test were performed using the same methods as before.

The safety requirements detailed in the specifications were satisfied, i.e.:

- No violent pyrotechnical reaction with splinter projection produced by fuel fire.
- Increase of velocity threshold of 12.7 mm AP bullet producing violent pyrotechnical reaction (deflagration) : this velocity threshold was increased by more than 150 m/s with respect to that obtained with the first generation EXOCET warhead containing a composition-B loading.

The second generation EXOCET warhead has been in service in the French Navy since 1986.

4. CURRENT AND FUTURE WORK

In the field of anti-ship warheads, the ANS missile currently under development has benefitted from the work described in the preceding paragraph. Insensitivity has been improved by optimization of the HMX granulometric size.

The successful compromise between ballistic performance and insensitivity provided by the plastic-bonded explosives has led to initiating development of the warhead for the ASTER anti-aircraft missile using this type of explosive.

In the anti-tank field, the terminal efficiency remains the primary goal. However, the safety level of the TRIGAT-MR warhead has been evaluated as of the debugging phase by fuel fire and bullet impact tests per STANAG 4240 and 4241 standards.

The SNPE work on ONTA explosives are currently considered as the main research channel in view of obtaining a level 3 insensitivity, i.e. non-propagation by sympathetic detonation. In collaboration with the SNPE, a study has been initiated to evaluate a type B3017 composite (74% ONTA, 26% binder and miscellaneous) as an explosive loading for shaped charge. This composition provides a good energy level for this type of application. Planned in this study are three sympathetic detonation tests using a test configuration similar to that shown in figure 2. If successful, the perforation performance of the shaped charge will be evaluated.

The preceding study is general in nature. Currently, no specifications for conventional weapon systems under development by AEROSPATIALE contain safety requirements (except for ANS) issued by the French Ministry of Defence. We believe this situation should be changing soon, producing a decisive move forward for research relative to insensitive missiles in France.